CURSOS DE VERANO POLITÉCNICA DE MADRID

HALA! SESAR Research Network
Summer Course

"Conformance monitoring, contract of objectives, tube in the sky"

COURSE 102: RESEARCH IN DECISION SUPPORT SYSTEMS FOR FUTURE AIR TRAFFIC MANAGEMENT

Outline

- Role of the Conformance Monitoring in the current and future ATM
- Overall Operational and Functional requirements for Conformance Monitoring

Key objective: Call for your attention about the Decision Support Systems, in particular: **Conformance Monitoring**

Major Question in ATM

- Should the aircraft adapt its flight to the ground segment requirements?, or
- Should the ground segment adapt its way of working to aircraft requirements?

Key question: Who is the customer?

Do Aircraft and Ground segment speak the same "language"?

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Aircraft

- Preferred routes
- Performance:
  - Lateral navigation
  - Vertical navigation
  - i4D
  - CDA/CCO

How to mach?

Ground segment

- Predefined routes
- Same routes: Conventional + RNAV
- Same speed
- Performance:
  - Lateral navigation
  - Vertical navigation
  - CDA/CCO

Answer:

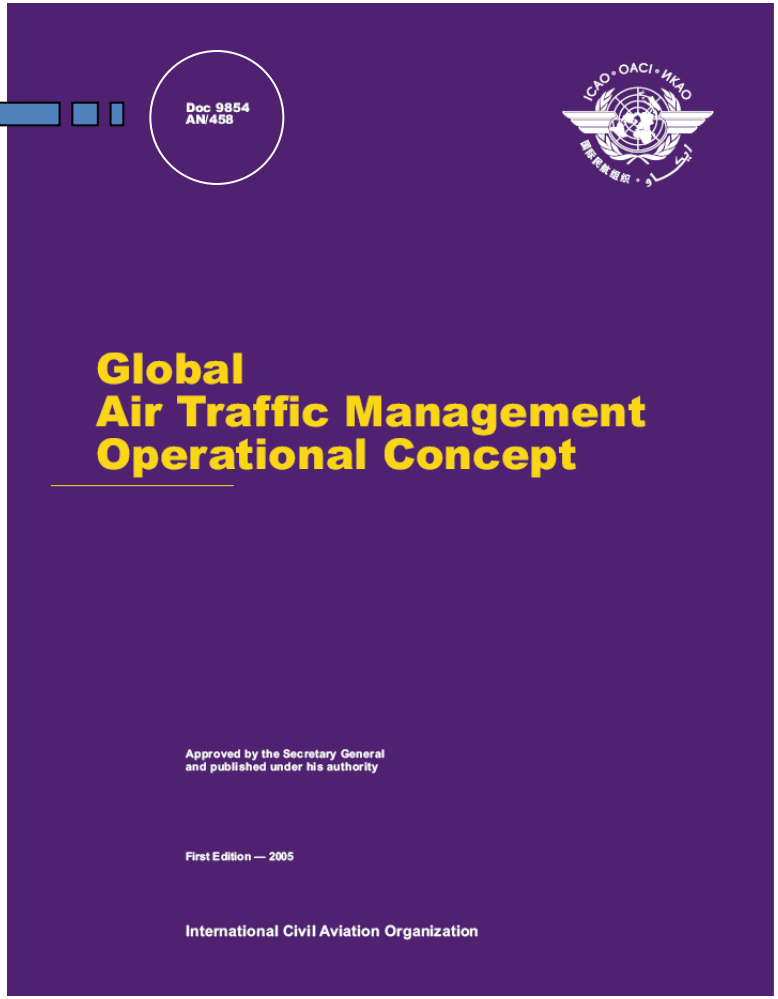
- **Near term: Step 1**
- **Medium term: Step 2**
- **Long term: Step 3**

Evolution process: From "Same service for every one" to "Best equipped, best served"

Reference Document: ICAO

Doc 9854
AN/458

This operational concept describes the services that will be required to operate the global air traffic system up to and beyond 2025



Air Traffic Control Service

- A service provided for the purpose of:
  - **Preventing collisions**
  - Expediting and maintaining an orderly flow of air traffic

Key word: Separation

Conflict Management

Conflict Management (ICAO)

- The function of conflict management will be to limit, to an **acceptable level**, the **risk of collision** between aircraft and hazards

Key concept: Acceptable level of risk

Conflict

Risk of collision ⟺ **Conflict**

- Is any situation involving aircraft and hazards in which the applicable separation minima may be compromised.
- Hazards that an aircraft will be separated from are: Aircraft, terrain, weather, wake turbulence, incompatible airspace and, when an aircraft is on the ground, surface vehicles and other obstructions on the apron and manoeuvring area

Key ideas:
- Risk of collision → Acceptable level → Separation minima
- Conflict is inherently a potential future aircraft situation

Conflict horizon

- Is the extend to which hazards along the future trajectory of an aircraft are considered for separation provision
  - Near term: 4-6 minutes
  - Medium term: 20 minutes

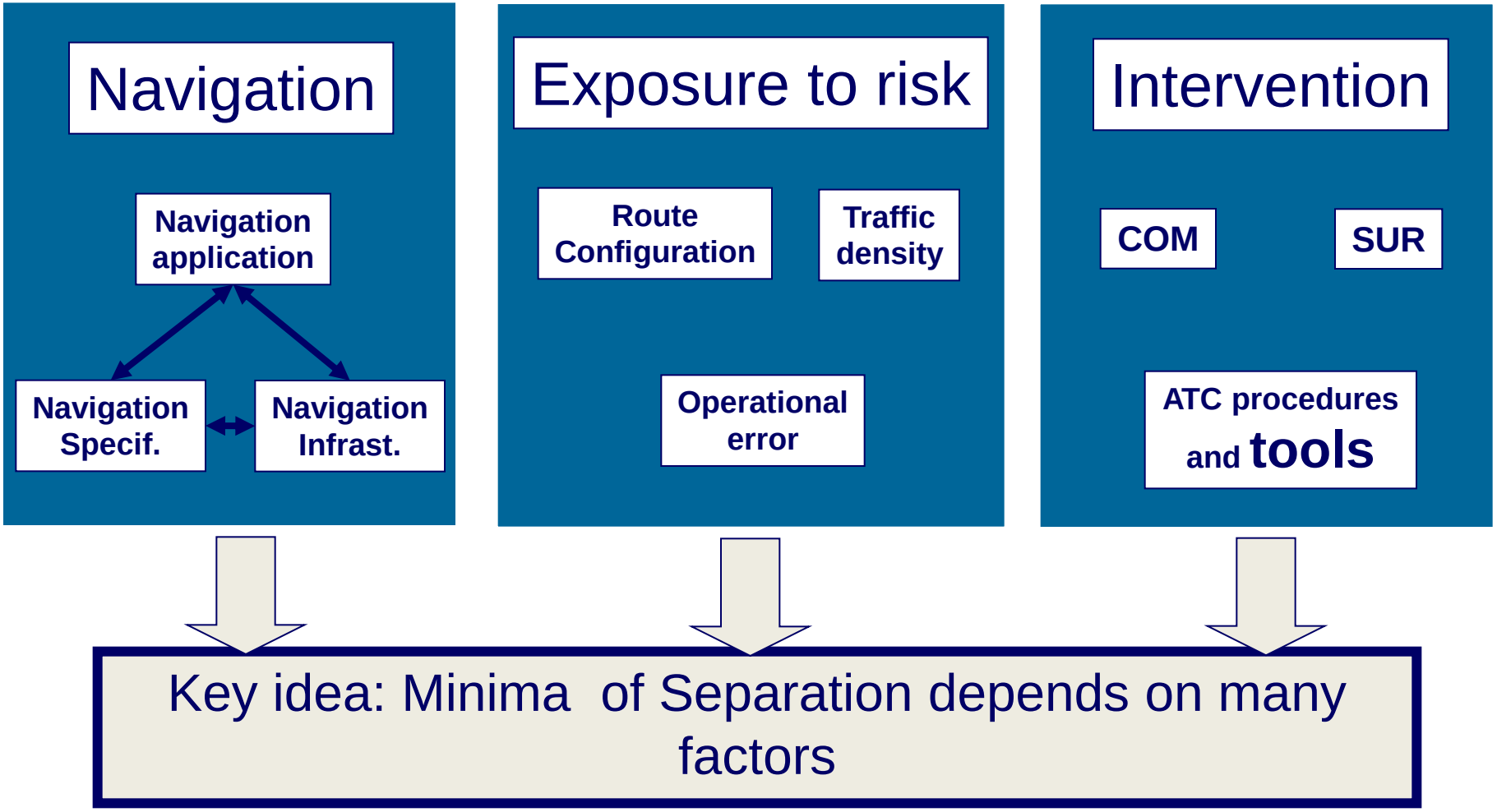
Key idea: Conflict horizons should be different for Planner and Tactical controllers

Separation minima

- Are the minimum displacements between an aircraft an a hazard that maintain the risk of collision at an acceptable level of safety.

Key idea: Separation minima is the “minima”, therefore actual separation is longer than the minima

Separation minima (Factors)



Separation provision

- Is the **tactical** process of keeping aircraft away from hazards by at least the appropriate separation minima
  - Planner controller
  - Tactical controller

Separation Mode

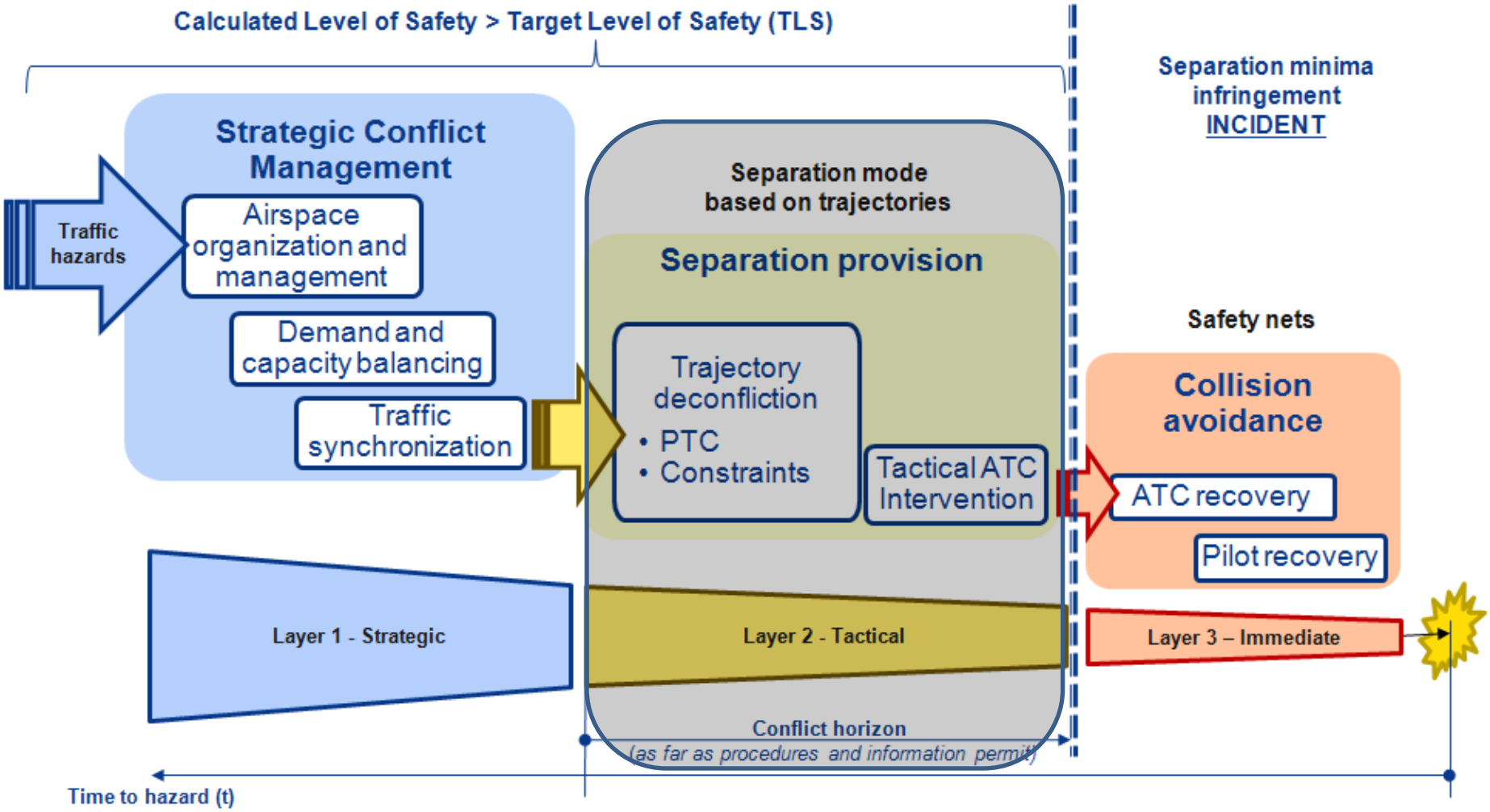
- Is an **approved** set of rules, procedures and conditions of application associated with separation minima.

Conflict Management

- **Currently**, conflict management is mainly a **tactical** activity.
  - The Tactical ATCo monitors aircraft separation continuously and takes corrective actions as required.
  - The actual separation is highly dependent on the human being.

Key idea: It is needed to implement new processes and tools to help ATCo in his work

Conflict management layers (ICAO)



Strategic Conflict Management

- The term strategic is used to mean **“in advance of tactical”.**
- Strategic actions will normally **occur prior to departure**; however they are not limited to pre-departure, particularly in the case of longer duration flights.
- Strategic conflict management measures **aim to reduce the need to apply the second layer: separation provision**.

Separation Provision

- It is the second layer of conflict management.
- It is the **tactical** process of keeping aircraft away from hazards by at least the appropriate separation minima.
- It will only be used when strategic conflict management can not be used efficiently.
- It is an **iterative process**, applied to the conflict horizon. It consist of:

  Detection of the conflict: "Conflict Detection"
  Formulation of a solution: "Conflict Resolution"
  Implementation of the solution, and
  Monitoring of the execution of the solution: "Conformance Monitoring"

Collision Avoidance

- Collision avoidance is the third layer of conflict management and must be activate when the separation minima has been compromised.

- **Collision avoidance is not part of separation provision**, and collision avoidance systems are not included in determining the calculated level of safety required for separation provision.

- Collision avoidance systems will be considered as part of ATM safety management.

- Collision avoidance functions and the applicable separation mode, although independent, must be compatible.

Solving conflicts in separation provision layer

ATC ⟺ Separation

- Conflict detection
- Conflict resolution
- Implementation of the solution
- Monitoring of the solution

Key word: Monitoring is essential in conflict management

Conformance Monitoring

- Monitors the **aircraft position** related to the planned/cleared trajectory

Key question: aircraft position: Current or future?

Aircraft position

- Current position:
  - Radar data
  - ADS-B
- Future position
  - ADS-B
  - Trajectory prediction

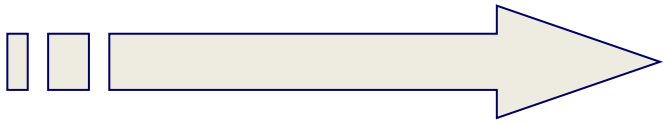
Key idea: Current position is not sufficient for the future Conformance Monitoring

Conformance monitoring in step 1

- Planned Trajectory
- Cleared Trajectory
- Coordinated Trajectory
- Deviated Trajectory

Key idea: For each aircraft there are 4 trajectories, Conflict detection should work with all of them. Conformance monitoring?

Trajectory Prediction

Time based  Trajectory based

- Trajectory prediction by the aircraft
- Trajectory prediction by the ground segment

Key ideas:

•Trajectory prediction is the cornerstone for ATM automation tools.
•Criteria for predictions may be not the same in ground and in air.

Trajectory prediction

- En-route: 2D
- TMA: 3D, 4D
  - STAR/SID
  - Take-OFF

Key idea: Predictions in 2D, 3D & 4D will be required

Conformance monitoring in the separation provision

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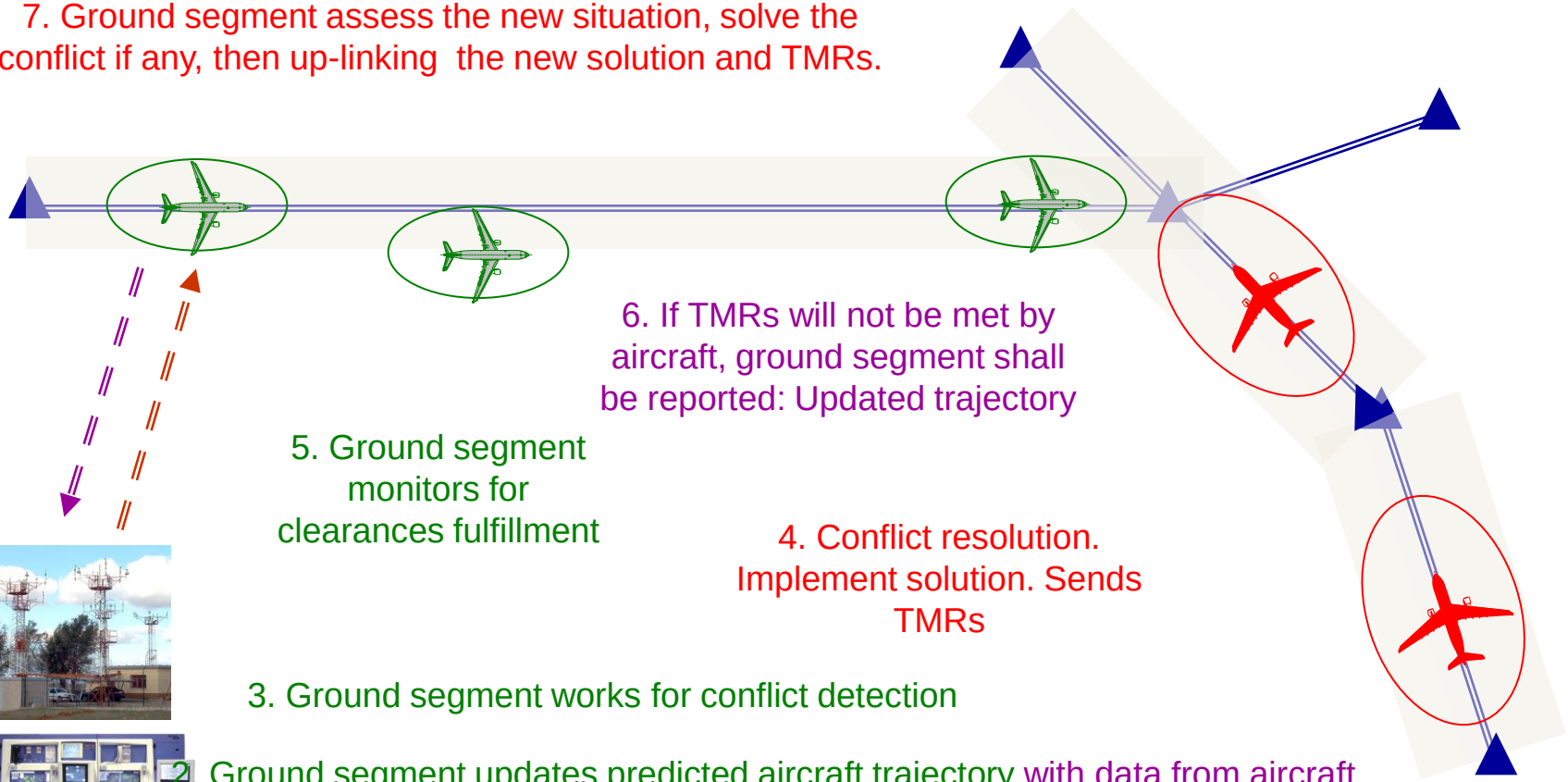
7. Ground segment assess the new situation, solve the conflict if any, then up-linking the new solution and TMRs.



6. If TMRs will not be met by aircraft, ground segment shall be reported: Updated trajectory

5. Ground segment monitors for clearances fulfillment

4. Conflict resolution. Implement solution. Sends TMRs

3. Ground segment works for conflict detection

2. Ground segment updates predicted aircraft trajectory with data from aircraft

1. Ground segment predicts aircraft trajectory

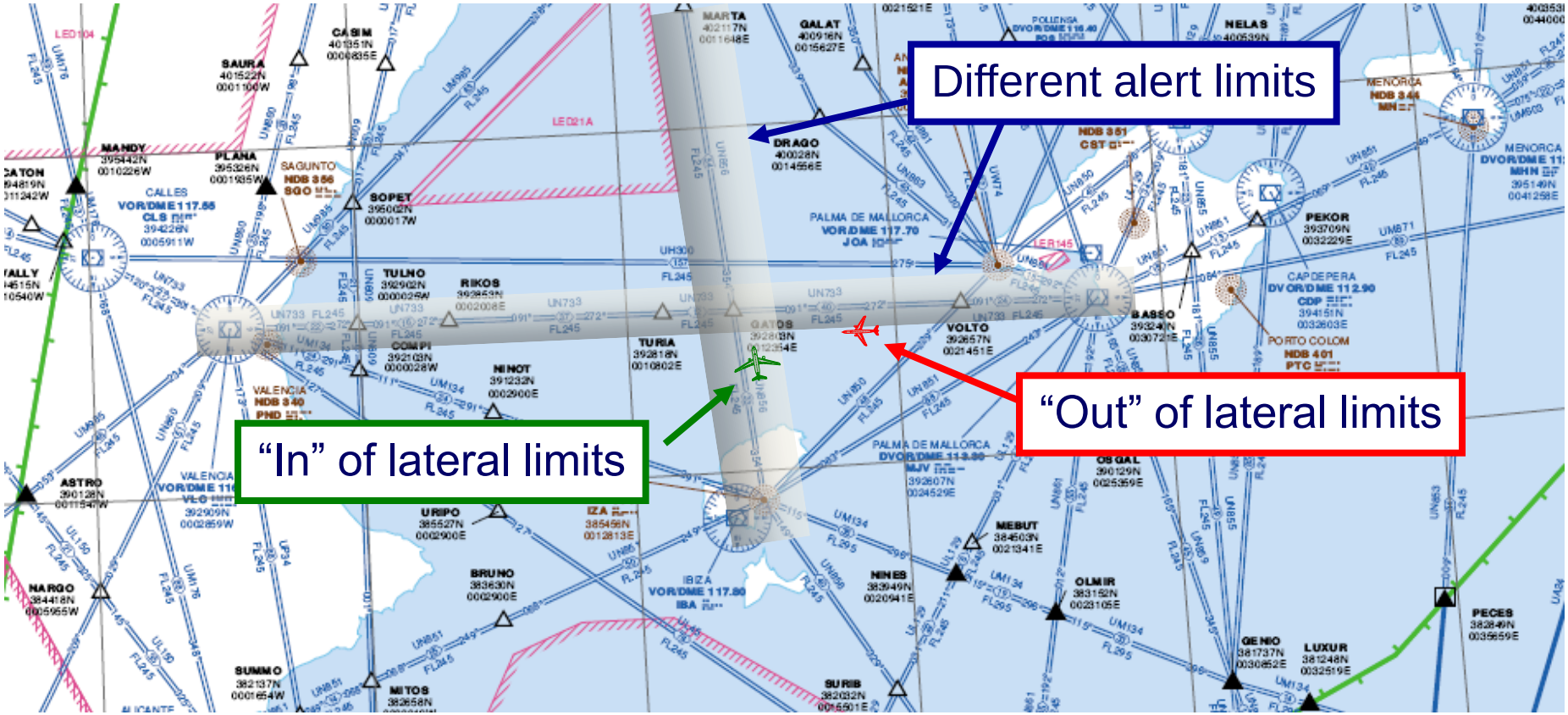
Conformance Monitoring objective (Step 1)

- The main purpose for conformance monitoring is to provide reliable **automated assistance** to the controller in their routine tasks, especially in busy traffic situations. Appropriate system support will assist **in relieving (NOT replacing**) the human monitoring workload and freeing mental resources of the controller for other tasks and/or traffic management.

Conformance Monitoring requirements

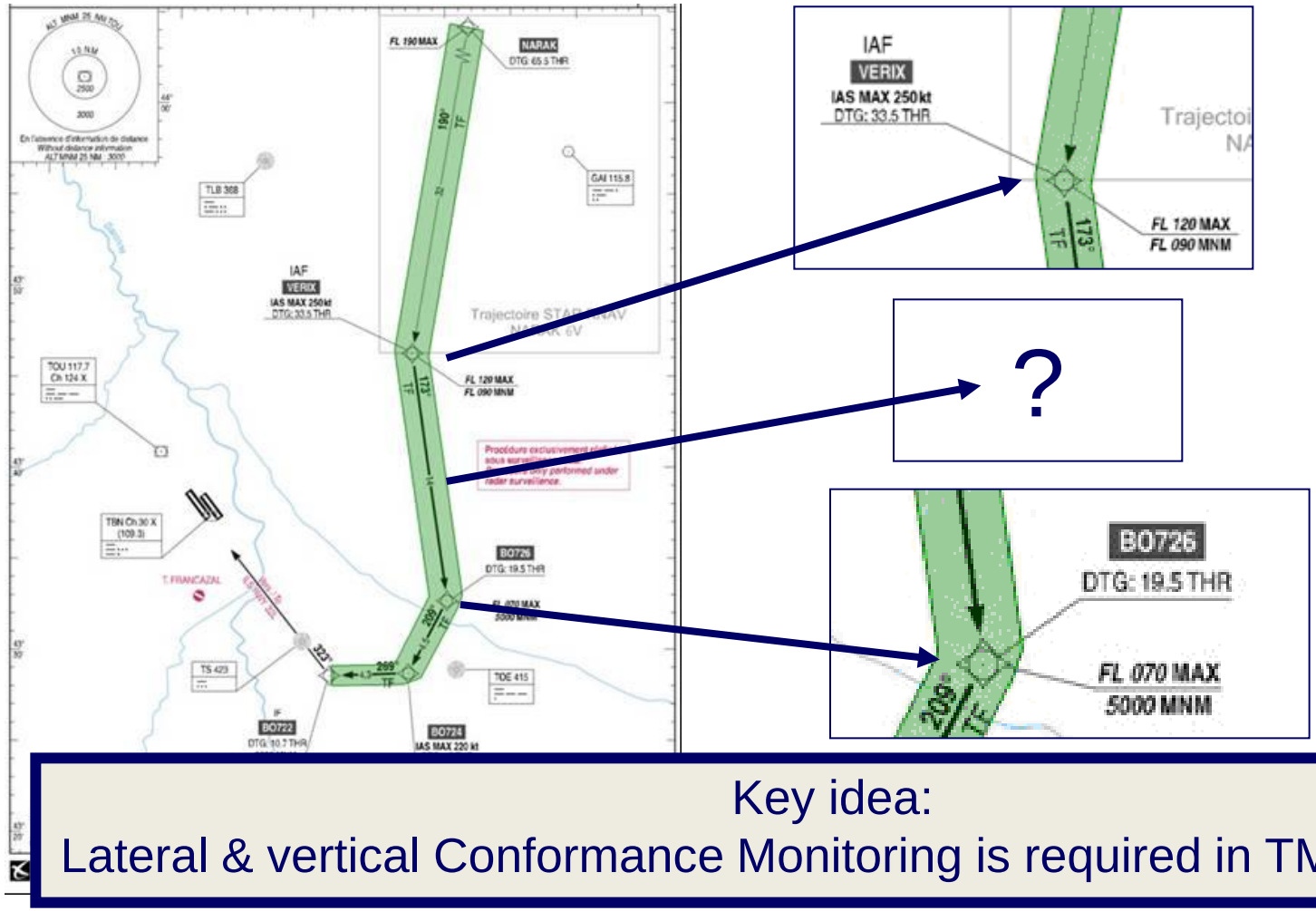
- Lateral: Different thresholds (PBN applications)
- Vertical:
  - In particular waypoints
  - Along the path
- Longitudinal: Time

Lateral conformance monitoring



Key idea: Lateral Conformance Monitoring is mainly applicable for the en-route phase of flight

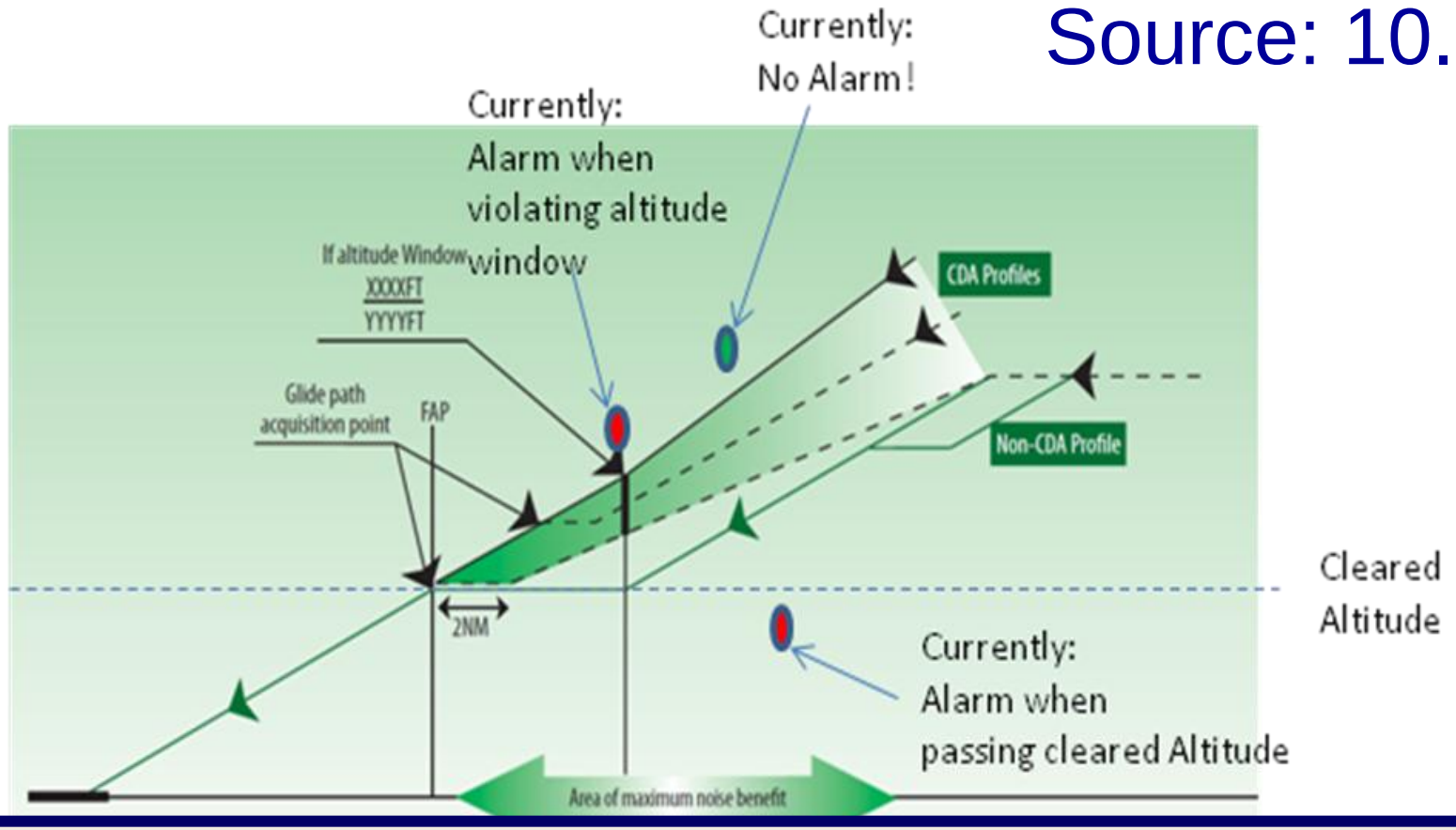
Lateral & vertical conformance monitoring



Key idea:
Lateral & vertical Conformance Monitoring is required in TMA operations

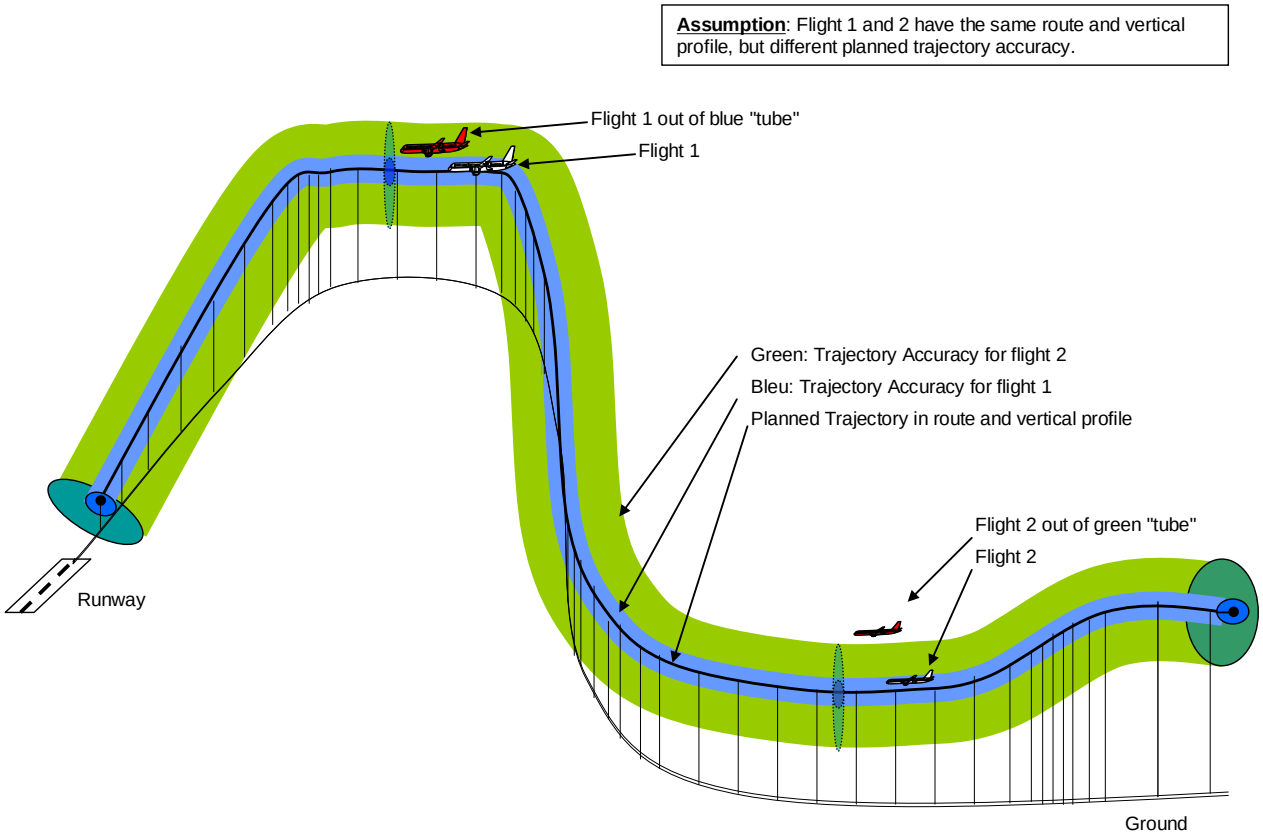
Conformance monitoring (Vertical dimension at fixed windows)

Source: 10.4.2



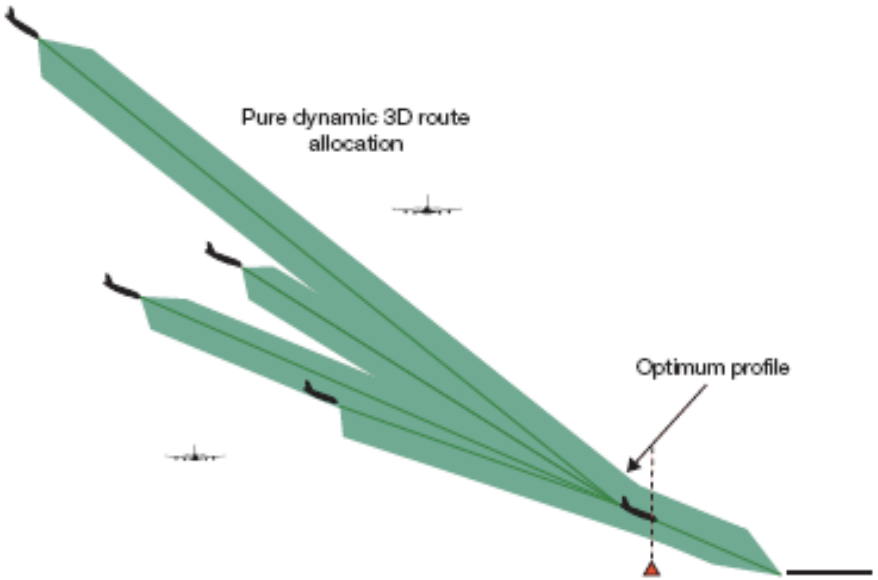
Key idea: In TMA, Vertical Conformance Monitoring should be required along the complete path

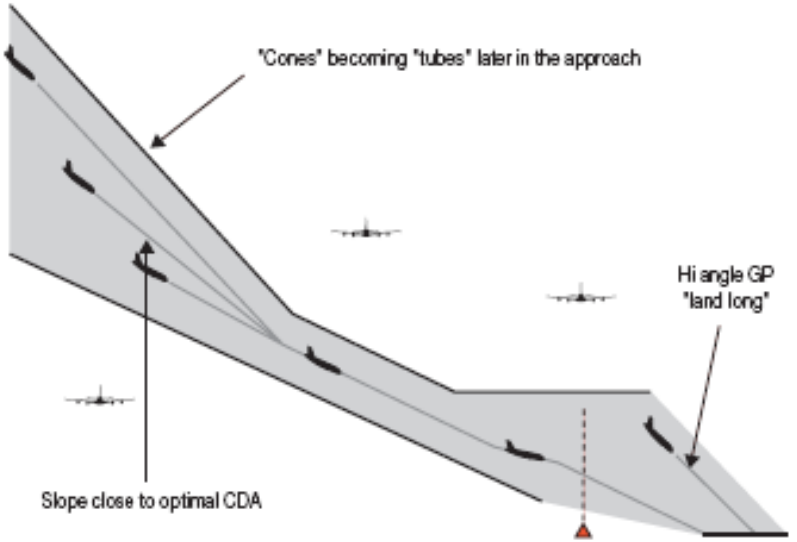
Lateral & vertical conformance monitoring: Tubes



Source: 10.4.2

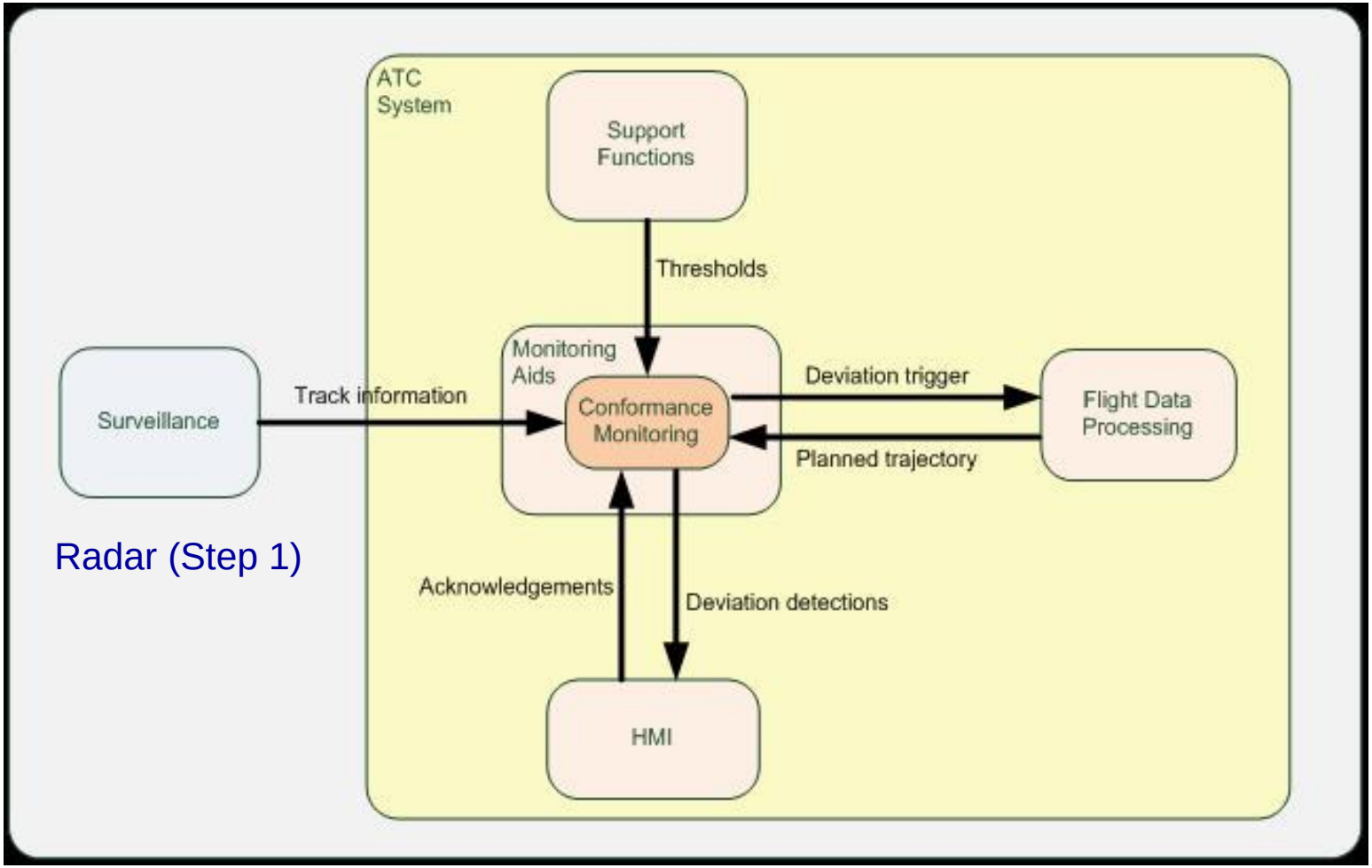
Tubes and cones





Key idea: Vertical navigation requirements are not common for ground and airborne

Conformance monitoring system



Radar (Step 1)

Operational and functional requirements step 1

- Will monitor that aircraft flown trajectory strictly conforms to the planned/cleared trajectory.
- ATC Controllers will have to be alerted if any discrepancy is detected.
- Will work with current positions
- Vertical navigation (vertical containment) is not available in the aircraft, then vertical conformance at determined waypoints.
- In TMA, conformance monitoring will apply to Continuous Descent Approach (CDA) with the continuous trajectory monitoring in the vertical dimension and adaptable lateral thresholds for different trajectory accuracies
- En route: 2D Conformance monitoring
- TMA: 3D and i4D

Operational and functional requirements step 2

- Will monitor current and predicted positions
- Predicted positions can be obtained from another system in the ground segment or from the aircraft.
- The best prediction is achieved on the aircraft.
- Updated predictions will be frequently required

Conclusions

- Conformance monitoring is not an independent tool, however is a key tool in the conflict management
- Monitoring should be not only for the present position, but also for the predicted trajectory.
- In TMA the conformance monitoring shall work in lateral and vertical dimensions. Desirable 4D
- Vertical dimensions shall be monitored not only in particular waypoints, but also along the path.
- Variable lateral thresholds: PBN specifications

Thank you for your attention!